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Twenty-eight Foundries to be Mechanised

Last Monday practically every daily newspaper told its readers of the proposed expansion of the iron and steel industries of this country to be carried through during the next five years. It is a bold plan and we in conjunction with the whole of the foundry industry congratulate the British Iron and Steel Federation on their enterprise and also upon the great contribution they have made towards winning the war. It was also very kind of them to give a free boost to the foundry industry by informing the world at large that to enable the public to be properly housed no fewer than 28 foundries are to be mechanised for the mass production of builders' castings. Everyone in the inner circles of our industry was well aware that many schemes were going forward—some smoothly, others having difficulty in getting the necessary sanctions, but of the statistical position they were abysmally ignorant.

Now that this disclosure has been made, there is a widespread desire to have more details in order that co-ordinated progress can be achieved, and it is vital to this end that the foundry industry be in possession of the following information: (1) Are these 28 foundries quite new projects to be created by the British Iron and Steel Federation? or (2) are these 28 foundries just a statistical aggregate of the schemes now being launched by members of the foundry industry? If the former be the case—which we doubt—then we invite the co-operation of the Federation with the organised activities of the foundry industry in order to prevent the possibility of chaotic conditions in this section of the foundry industry. If, on the other hand, the Federation has only taken upon itself to be the mouthpiece of the foundry industry, then all that can be said is "Thank you." The steel industry is somewhat remote from the manufacture of grey-iron castings and both in America and here it has taken a world war to teach them—in common with all other trades—that a flourishing foundry industry is a prerequisite to their existence. The steel industry ranks high amongst the consumers of castings. Its orders for ingot moulds, furnace doors, rolling mill plant, coke oven castings, are considerable. On the other hand, the foundry is an extremely important customer for pig-iron. Thus there is every reason for close collaboration, but at this stage of the commercial set up of the two industries, there is little reason for propagating the notion that an integration of interests is already *un fait accompli*.

Ironfoundry interests are linked with the iron section of the iron and steel industries through the existence of a joint council, upon which sit an equal number of representatives from each, and a director, Mr. Knowles, has recently been appointed but has not yet taken up his duties. No doubt when this new Council is properly functioning, the idea of the Federation publicising the work of the ironfoundry industry will become fantastic.

W. H. WHITTLE FOUNDATION AWARDS

The Council of the Institute of Vitreous Enamellers announce that arrangements have been made to award the prizes offered under the terms of the Whittle Foundation during the session 1945-46. This, the premier award offered by the Institute, carries with it a medal and a cash prize of 10 guineas, the assessors reserving the right to award a prize to runners-up in the case of specially meritorious entries.

While entries are invited from junior chemists or other technicians, war service will be taken into account in regard to age. Entrants are specially warned of the necessity of making sure that any information given in their Paper is not confidential. Full details may be obtained from the hon. secretary.

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CORRESPONDENCE

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

FOUNDRY COSTING

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have read your review of my booklet on foundry costing, and I am pleased to see that your criticism is generally favourable. Perhaps I may be allowed to deal with the matter of costs being right up to date. I think the important point is to get a sound basis to work from so that no items of cost are overlooked. The latest half-yearly balance-sheet forms such a basis. The trading accounts are generally audited by expert accountants, even in small foundries, so that no items affecting the cost would be overlooked. After establishing the man-hour cost in the balance-sheet period, adjustments to meet the variation due to subsequent alterations in wages, as well as in prices of materials, etc., can be made without difficulty, and with sufficient accuracy to give reliable costs for estimating purposes.

On the subject of waster castings, if only one is required and the first attempt proves to be a waster and a second has to be made to replace it, the total cost of the sound casting would be that of the second, plus that of the first, less the scrap value of the waster. These costs are easily ascertained. There is in addition a loss due to reduced output of reliable castings which is not so easy to calculate, but which would affect the profit and loss account.

The matter of apportioning overheads in the case of a really large one-off casting is one of the points I had in mind in dealing with the need for knowledge of engineering and foundry technique, as well as of accountancy, in dealing with costs. The expert founder would take into account the risk of a particular casting turning out a waster when quoting for it, and add a certain percentage to cover the risk.

Yours, etc.,

ARTHUR J. BURN.

Llanelly, South Wales.
July 16, 1945.

NEW CATALOGUES

High-Duty Cast Iron. The International Meehanite Metal Company, Limited, 66, Victoria Street, London, S.W.1, have issued a four-page leaflet specially designed to answer three questions about Meehanite—What is it? how to get it? and where to get it? These objectives have been well achieved, while for those in search of more detailed information there is listed about three dozen references to bulletins and technical Press articles. As a means of interesting a buyer new to the subject it is ideal.

Electric Lamps. Siemens Electric Lamps & Supplies, Limited, of 38/9, Upper Thames Street, London, E.C.4, have used a four-page leaflet (No. 976) to announce a reduction in the prices of their goods, and to illustrate and describe their characteristics. The issuing house will supply readers with a copy on request.

FALKIRK FOUNDRIES WAR EFFORT

Addressing the Rotary Club of Falkirk recently, Capt. H. J. Kennard, R.N. (retired), director of Allied Ironfounders, Limited, said that large orders for cooking and heating equipment were likely to come to Falkirk. This was as the result of research carried out during the past 18 months, chiefly on the instructions of the Ministry of Fuel and Power. In order to cope with this work it would be necessary to have the foundries properly equipped. In this respect the present position was serious owing to the lack of apprentices.

He did not think foundries would be mechanised because there was work, especially in the moulding shops, which would always require craftsmen. He was glad of that, for we did not want to turn into a nation of robots. Housing was one of the main problems, and builders' castings had always been Falkirk's chief line of production. He hoped that the appropriate Government department would see fit soon to derequisition foundry establishments which had been used for other work during the war period.

During the war the foundries in Falkirk and Bonnybridge had been able to step up production in catering and heating appliances for camps and for military and industrial canteens. One article of munitions which had not much changed since the 1914-1918 war was the Mills bomb, and during the recent war millions of those had been turned out by the Falkirk foundries, and production of those was still continuing. In Camelon, a mechanical plant was installed for turning out track links for tanks, and there was a very large production. At another foundry a forge plant for 25-lb. shells achieved 12,000 forgings a week—a considerable output for one small place. Cast-iron heads for 4-lb. incendiary bombs were turned out in millions in Falkirk.

FULL VISION TRAVELLING CRANE

One of the most radical innovations in many years in cab design for overhead travelling cranes, recently installed in a large U.S. metal-working plant, provides full vision for the operator, comfortable sit-down control and air conditioning. The new cab may be used with any new crane employing magnetic control and with existing cranes of any make. The cab, which is 6 ft. 6 in. high by 4 ft. 6 in. dia., was developed by the Cleveland Crane & Engineering Company, Wickliffe, O.

THE JUNE ISSUE of the "Nickel Bulletin" is now available on request from the Mond Nickel Company, Limited, Grosvenor House, Park Lane, London, W.1. The abstracts include a number of references to continuous casting processes and an extensive note on the determination of nickel and cobalt in ores. Under the electrodeposition section various methods of analysing nickel-plating baths are noted. Among the remaining abstracts is one outlining, in some detail, the method of determining titanium in high-alloy steels.

THE ANNEALING OF WHITEHEART MALLEABLE IRON BY A GASEOUS PROCESS*

Development of a practical and economical process on an industrial scale

By A. G. ROBIETTE, B.Sc.† (Member)

Introductory

This Paper sets out to describe a new gaseous process for the production of whiteheart malleable iron. It was developed early in 1941 but, for reasons mainly of security, it has not been possible to publish the results until now. There have been, from time to time, various suggestions for the elimination of iron ore or other packing materials, but the development of a practical and economical process on an industrial scale has, up till now, been lacking.

Before describing the process, it should be stated that it is the Author's intention to deal with the subject from an essentially practical standpoint, setting out the fundamental principles and showing how these, together with pilot-scale development work, have translated the process into a practical system for the annealing of whiteheart malleable. None of the results and conclusions is based upon experiments carried out in small laboratory muffles, where conditions are vastly different from actual practice; in fact, the bulk of the development work has been carried out on actual castings treated in a furnace capable of taking a load of up to 5 cwts. of castings. Some of the later development and some production work has been carried out in a production size batch type furnace installed in a malleable foundry.

For the purpose of this Paper, whiteheart malleable iron may be defined as any white cast iron which is intentionally decarburised during the process of annealing. It may or may not exhibit a white fracture, depending upon the number and size of the graphite nodules if these are present. The designation "malleable" is somewhat of a misnomer, its main justification being common usage. For very few, if any, applications is the property of "malleability" required, *i.e.*, the capacity of a material of being beaten or hammered into shape. For most engineering castings what is required is strength, rigidity and shock resistance, combined with good machining properties, whilst the ability to cast the material into thin, intricate sections possessing excellent surface finish distinguishes it from steel. These seemingly irrelevant remarks are being made here, as later in the Paper some suggestions are put forward for a revision of test requirements for whiteheart malleable, and indeed for a new perspective for what can be, with the advent of the gaseous process, a very much more versatile engineering material than hitherto.

* Paper presented at the 42nd annual meeting of the Institute of British Foundrymen, held in London, June 15 and 16, 1945.

† Consulting Metallurgist, H. A. Brassert & Company, Limited, (formerly, Chief Metallurgist, Birlec, Limited).

Iron-ore Process

Whiteheart malleable iron has been made for some 200 years by the Réaumur process of packing the castings in iron-ore mixtures, and although considerable improvements have been made in furnace design and the use of continuous kilns, there has been no radical change in principle until the development of the gaseous process. The shortcomings of the process, which are fairly widely appreciated in the industry, are inherent in any method of pack treatment, in which parts are treated in boxes packed with some "active" material. The thermal efficiency is bound to be low and the time cycle long, whilst the possibility of getting accurate control cannot be very favourable. It was felt that any process which could eliminate "pack" treatment would show very real economies and would possibly improve the average standard of quality of whiteheart malleable iron.

It is well known that in the iron-ore process the reactions between the ore and castings, although complex, are essentially gaseous, and it has been shown that the castings and the ore need not be in contact for decarburisation to proceed. Essentially, the carbon is removed as carbon monoxide, which is "regenerated" by partial reconversion to CO_2 by reaction with the hematite ore, which itself becomes spent. In effect, the oxidation of the carbon is effected by the oxygen in the ore, the transfer being carried out through a gaseous medium. If the temperature be too high or the ore too active, then an excess of CO_2 is formed, and oxide penetration into the casting will result. The reactions in the ore process are complicated by the initial presence of hydrogen, the presence of sulphur in the ore and by side reactions. The chemistry of this process has, however, been studied elsewhere.[1]

Theoretical Considerations

The physical chemistry of the gas-metal reactions involved in the gaseous process have been dealt with in some detail in the Appendix to this Paper. It is shown there that CO/CO_2 mixtures in certain definite proportions, which vary with temperature, will decarburise whiteheart malleable iron without causing any oxidation. Further, H_2/H_2O mixtures can likewise be controlled so as to decarburise malleable iron without oxidising the iron. Hydrogen alone is comparatively ineffective at high temperatures due to the large volume of hydrogen required to produce any considerable degree of decarburisation. It is also pointed out that the mixtures of CO/CO_2 and H_2/H_2O, which are only just on the reducing side of the equilibrium,

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are well on the decarburising side. These, therefore, are the mixtures which are recommended, as they have the maximum decarburising power, while at the same time they are completely reducing to iron.

The effect of diluting the gas mixtures with nitrogen is also dealt with, and it is shown that this has no effect on the CO/CO_2 and H_2/H_2O ratios required for the prevention of oxidation, but it has an effect on the ratios required for the decarburising reactions, but not to any extent that the decarburising power is seriously impaired. The main effect of dilution from a practical standpoint is that it reduces the number of molecules of decarburising gas per unit volume of controlled atmosphere passed over the castings. For instance, if a gas contains among other constituents, only 6 per cent. of CO_2, it will take approximately

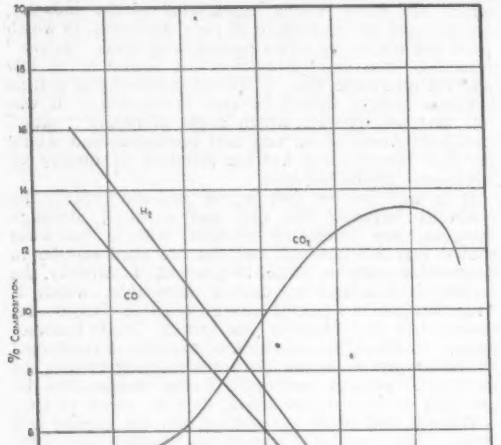

FIG. 1.—CURVES SHOWING THE COMPOSITION OF COMBUSTION PRODUCTS FROM TOWN'S GAS BURNT TO DIFFERENT AIR/GAS RATIOS.

five times as much gas to produce the same amount of decarburisation as a gas containing 25 per cent. CO_2.

The most readily available sources of controlled CO/CO_2 and H_2/H_2O gas mixtures are produced by the partial combustion of fuel gases, such as town's gas, coke-oven gas, producer gas, and carburetted water gas. Fig. 1 shows the composition of gas mixtures produced by the partial combustion of Birmingham town's gas with various air-to-gas ratios. The curves

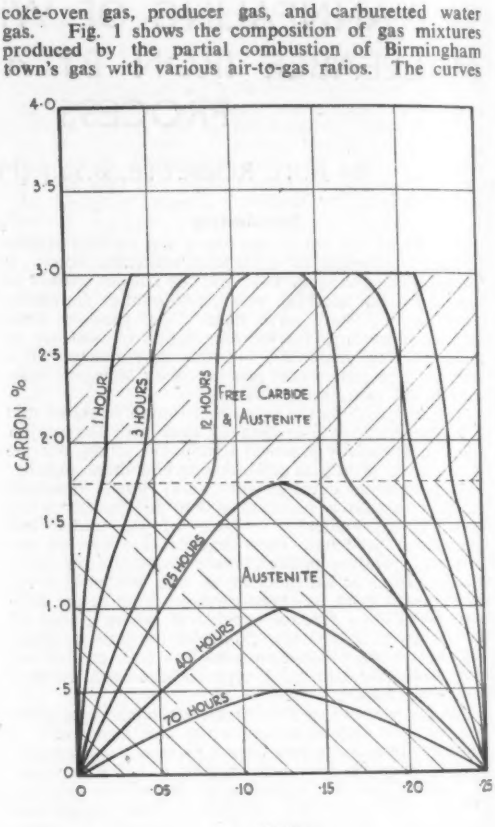

FIG. 2.—CARBON DISTRIBUTION IN ½-IN. BAR DECARBURISED FROM BOTH SIDES FOR DIFFERENT PERIODS (DIAGRAMMATIC).

are drawn for the combustion products, from which water vapour has been removed, down to a figure of 2.5 per cent., and the balance of the composition is nitrogen (neglecting the rare atmospheric gases). With an air/gas ratio of 2.5 to 1, the products of combustion after cooling to remove water vapour to 2.5 per cent. contain 11 per cent. H_2, 9 per cent. CO, 6.2 per cent. CO_2 and 2.5 per cent. H_2O, the balance being nitrogen. This gas when it enters the furnace (neglecting the CH_4 content) will reconstitute itself to be in equilibrium with the water gas reaction, and the furnace atmosphere will contain approximately 8.0 per cent. H_2, 11.2 per cent. CO, 4.0 per cent. CO_2, and 5.5 per cent. H_2O.

It is shown in the appendix that this mixture is decarburising, but non-oxidising, to malleable iron at 1,050 deg. C., and it constitutes a gas mixture which can be readily used for the annealing media in place of iron ore. It can also be shown that partially burnt producer and other fuel gases are equally effective.

Practical Gas Consideration

It has been shown that the effect of dilution with nitrogen is to increase the volume of decarburising gases required, and it is quite simple to calculate the

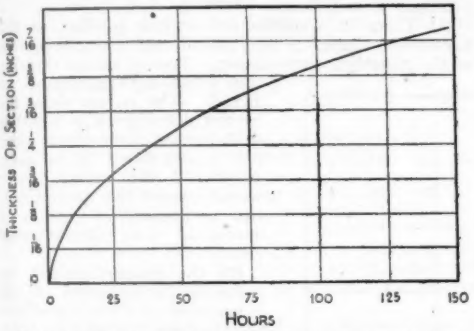

Fig. 3.—Curve showing Relationship between Depth of Decarburisation to an Average Carbon Content of 0.5 per cent. in a Period of Annealing at 1,050 deg. C.

theoretical volume of gas required to decarburise a given charge of castings. This has a very important bearing upon the economy of using partially burnt fuel gases, and the following example is typical of what would be expected in practice.

Consider the annealing of 1 ton of castings containing 3.2 per cent. carbon and assuming it is required to end up with the final average carbon content of 0.5 per cent. C., this will mean the removal of

$$\frac{2{,}240 \times 2.7}{100} = 60.48 \text{ lb. of carbon.}$$

1 cub. ft. of CO_2 reacts with 0.034 lb. of C.

Also 1 cub. ft. of H_2O reacts with 0.034 lb. of C.

These gas volumes are at N.T.P. Taking the burnt coal gas example previously considered, it was shown that in the furnace the composition was 4.0 per cent. CO_2 and 5.5 per cent. H_2O. Assuming that 2.5 per cent. CO_2 and 3.0 per cent. H_2O are reactive, which is a fair assumption from practical results, it will be evident that 100 cub. ft. of the atmosphere will remove $2.5 \times 0.034 + 3.0 \times 0.034 = 0.187$ lb. of carbon, so that to remove, say, 60 lb. of carbon will mean the use of 31,900 cub. ft. of atmosphere.

This is based on the assumption that practically all the gas passes over all the surfaces of the castings. In the best designed furnace, there must be clearances between the charge and the furnace walls, and it is practically impossible to prevent some gas from bypassing the charge. Moreover, the rate of carbon removal in the early stages of the heat is several times that experienced in the later stages, so that an excess of gas must be available to ensure that the maximum rate of decarburisation is obtained. It has been found in practice that the theoretical gas requirements have to be approximately doubled to ensure optimum results. This means that 63,000 cub. ft. of atmosphere is required per ton of castings annealed. This would require about 22,000 cub. ft. of raw coal gas, which, at 2s. 6d. per 1,000 cub. ft., means an expense of £2 15s. per ton. With purified producer gas, this cost could be reduced to about £1 15s. per ton of castings annealed.

To check this gas consumption figure, a 15-cwt. charge of light castings was annealed for 36 hrs. in a 7-ft. long by 3-ft. 9-in. wide by 1-ft. 6-in. high, batch-type furnace, and it was found that the raw coal gas consumption per hour to produce the atmosphere was 450 cub. ft. per hr. This meant a total consumption of 15,700 cub. ft. for the charge, or 20,930 cub. ft. per ton, which agrees within 5 per cent. of the calculated figure.

It occurred to the Author[3] that this was an essentially wasteful process in that the spent gas could be regenerated by mixing with it sufficient air to reconvert the CO to the original CO/CO_2 ratio and, similarly, the H_2 to the correct H_2/H_2O ratio. A recirculation process was then developed which theoretically meant that the furnace need only be filled with an atmosphere to start with, and this gas could be used over and over again. In fact, its volume increases progressively as decarburisation proceeds, since

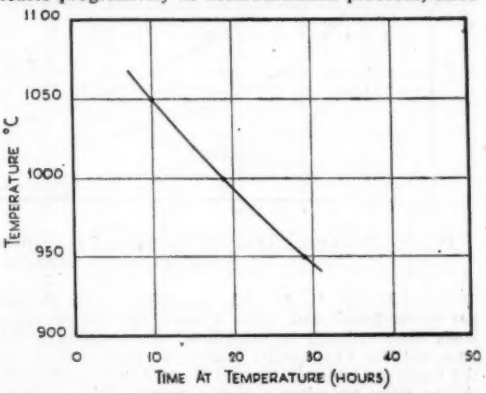

Fig. 4.—Relationship between Time of Annealing at Different Temperatures to Produce an Average of 0.5 per cent. Carbon in ½-in. Thick Casting.

the reaction between C and CO_2 produces two volumes of CO. In other words, the furnace is acting as a producer, producing, with the controlled air addition

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into the system, the correct atmosphere from the carbon in the castings. The recirculation of the gas can be done outside the furnace or inside the furnace. In practice, it is normally necessary to provide a make-up of gas to balance losses from the system. It is almost impossible to make any furnace which has to be charged and discharged conveniently absolutely gas-tight. At any rate, the provisions required for doing so would be too elaborate, especially for a furnace operating at 1,050 deg. C.

The gas regeneration system was fitted to a furnace annealing up to 15 cwts. of castings per charge, and the amount of raw coal gas used was cut down from 450 to 150 cub. ft. per hr. In other words, the raw gas consumption and, what is more, the gas operating costs were reduced to one-third. This was in a furnace without any special means for door sealing and the main gas losses in a batch furnace with a vertically sliding door are always at this point. On a furnace with three times the capacity, the door area need not be increased, with the result that the gas consumption on this basis would mean that only one-ninth of the calculated gas consumption of 22,000 cub. ft. would be required. In other words, the gas costs with recirculation in a horizontal batch-type furnace holding 2 to 3 tons of castings are approximately 7s. per ton (after adding the cost of running recirculation fans).

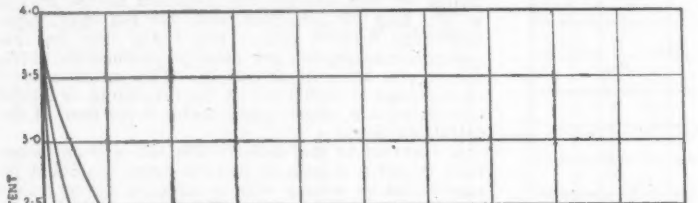

FIG. 5.—AVERAGE CARBON CONTENT OF ¼-IN. THICK CASTING DECARBURISED FOR DIFFERENT PERIODS.

Rate and Mechanism of Carbon Removal

It was often held that in the mechanism of carbon removal the CO_2 penetrated into the castings (presumably along grain boundaries) reacting with the carbon and presumably finding its way out as CO. The Author can find no evidence that CO_2 or CO is soluble in solid iron at these temperatures, whereas the evidence in favour of the theory that the carbon is removed by reaction at the surface and the carbon diffuses to the surface from the centre of the castings appears to be unassailable. Briefly summarised, the evidence is as follows:—

(1) There is a continuous carbon gradient in the decarburised layer as long as only one phase is present at the annealing temperature. Typical curves showing this effect are reproduced in Fig. 2. The curves show the carbon distribution in ¼-in. bar decarburised from both sides for various times. If the gases penetrated the material, one would expect the decarburisation to proceed in a series of deepening fully decarburised zones.

(2) The process is the reverse of carburisation, which is accepted as a process of surface reaction followed by diffusion. It follows the diffusion law from which the carbon content, at different depths, can be quite closely calculated.

(3) The rate of removal of carbon from the surface plotted against time (see Fig. 6) is a hyperbolic function which would be expected if the limiting factor were the rate of diffusion of carbon (always assuming adequately decarburising conditions).

(4) Subject to the variation caused by the presence of free carbide or graphite, the mechanism of decarburisation, as will be shown, can be predicted from the diffusion constant for carbon in gamma iron.

(5) It is found that the rate of decarburisation falls off below 880 deg. C. at a greater rate than would be expected from the diffusion law, due to the presence of ferrite, and as the temperature approaches Ac_1, ferrite rims become apparent, due to the low solubility of carbon in alpha iron. In passing, it is interesting to note that this occurs in the iron-ore process, since decarburisation occurs at these lower temperatures owing to the long cooling time.

It can safely be said, therefore, that the rate of decarburisation, providing there is an adequate flow of decarburising gas, is only limited by the rate of diffusion of carbon, which is mainly a function of tem-

perature. This equally applies to the iron-ore process. The mechanism of decarburisation is, therefore, a problem in chemical kinetics, namely, the diffusion of a solute in a solvent, the solute being carbon and the solvent gamma iron. It obeys Fick's Law, which says that the rate of passage of solute diffusing under any given condition is proportional to the concentration gradient and the area through which it diffuses. As the concentration gradient is continuously changing as diffusion proceeds, the expression for the amount of carbon diffusing involves the solution of a differential equation. J. K. Stanley,[3] using the van Orstrand-Dewey solution, has shown that the expression to calculate the rate of removal of carbon from austenite is

$$C = C_o - C_o\left[1 - \phi\left(\frac{x}{2\sqrt{Dt}}\right)\right]$$

where

C = carbon content at point x in per cent.
C_o = carbon content in immediate surface.
ϕ = Gauss error integral.
D = the diffusion constant in sq. cm. per sec.
t = time in seconds.
x = in cm.

It is pointed out that the time t is not the total time at temperature, but is the time recorded after the period required to bring the carbon content on the surface to zero.

It will be seen that the depth of decarburisation is proportional to $\sqrt{t}$. In other words, to produce twice the depth of decarburisation requires four times the time. If it requires 10 hrs. to decarburise a casting ¼ in. thick, it will take 40 hrs. to decarburise one ½ in. thick, or 90 hrs. to decarburise one ¾ in. thick to the same carbon content. This agrees with the curve, Fig. 3, plotted from an average of dozens of determinations on actual castings.

Moreover, the depth of decarburisation is also proportional to the square root of the diffusion constant. This latter varies with temperature in accordance with the exponential function.[4]

$$D = (0.07 + 0.06 \times \text{per cent. C})\, e^{-\frac{32000}{RT}}$$

where R = the gas constant.
T = absolute temperature.

The variation of D with temperature is given in Table I, and as the depth varies as the square root of

TABLE I.—*Variation of Diffusion Constant with Temperature.*

Temp., deg. C.	D (cm.²/sec.).
900	1.4×10^{-7}
950	$2.4 \times$,,
1,000	$4.1 \times$,,
1,050	$6.2 \times$,,
1,100	1.0×10^{-6}

D, a very small change in temperature, even 50 deg. C., will very considerably increase the depth of decarburisation. There is another factor which also enters into the change in temperature, namely, the solubility of carbon in gamma iron which changes the concentration gradient as well. The above considerations are useful in that they give a close indication of the effect of temperature, time and thickness of specimen, but it should be remembered that they apply only to the diffusion of carbon in austenite. They cannot be applied directly to whiteheart malleable—only comparatively—since there may be two or even three phases present (austenite, carbide and graphite), and the presence of other phases would in the nature of things restrict the free diffusion of carbon. The curve, Fig. 4, experimentally determined, shows the time required to reduce the carbon content of a whiteheart malleable casting originally containing 3.8 per cent. C., ¼ in. thick, to an average of 0.5 per cent. at different temperatures: whereas at 1,050 deg. C. it takes 10 hrs., at 1,000 deg. C. it takes 19 hrs., and at 950 deg. C. 29 hrs. The carbon determinations were done by analysis by drilling through the casting.

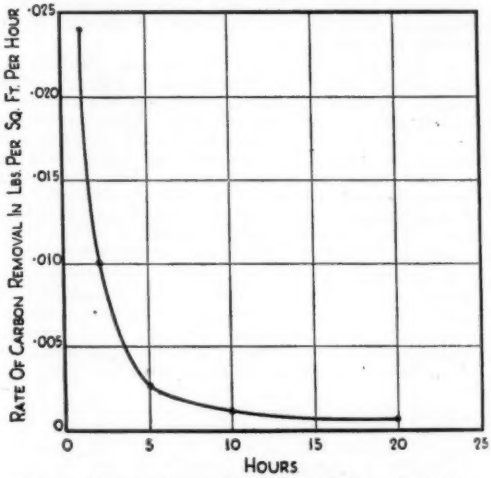

FIG. 6.—RELATIONSHIP BETWEEN CARBON REMOVAL PER SQ. FT. OF SURFACE PER HR. AT 1,050 DEG. C. AND TIME AT TEMPERATURE (¼-IN. THICK CASTINGS).

The decarburisation was effected in an atmosphere of burnt town's gas.

The curves, Fig. 5, show the average carbon content of ¼-in. thick castings decarburised for various times at temperatures of 950 deg. C., 1,000 deg. C., and 1,050 deg. C. They serve to show the effect of temperature and they emphasise the high initial rate of carbon removal which can be predicted from the diffusion law.

From the above considerations, it is evident therefore that to obtain the shortest cycle it is necessary to operate at as high a temperature as possible, the temperature being limited only by the tendency of the castings to distort or even "squat" or collapse

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under their own weight. This temperature is higher than what is possible in the normal iron-ore process for several reasons. In the gaseous process, the castings can be stacked in tiers with a very low superimposed weight of load and, as the temperature throughout the load can be maintained automatically within ± 5 deg. C., no factor of safety need be allowed. Moreover, it is impossible to obtain oxide penetration or peeling in the gaseous process, as the atmosphere is controlled so that no iron oxide can be produced.

From experience gained during the annealing of hundreds of different types of casting, it has been found that the best temperature for annealing in the gaseous process is around 1,050 deg. C. It may be possible to anneal certain heavy, well-supported castings at 1,070 deg. C., but it has been found that this procedure is risky, there being little margin of safety. For most castings it has been found in practice that a height of stack of 9 in. produces no appreciable distortion at 1,050 deg. C.

It has been pointed out that the rate at which carbon is removed from the castings is greatest initially and, as the time of annealing increases, the amount of carbon removed progressively falls. The curve, Fig. 6, shows the relation between the weight of carbon removed per square foot of surface per hr. at 1,050 deg. C., and the time at temperature. These tests were done on sample castings ¼ in. thick, of which the area was determined, and they were rapidly cooled in the same atmosphere to prevent oxidation. The determination of carbon loss was then done by weighing.

From these tests it is possible to determine the amount of gas produced during the annealing treatment. The carbon is removed as CO, and by the recirculation and admixture of air it is partially converted to CO_2. In effect, the CO is oxidised with air, which is approximately 79 per cent. N_2, 21 per cent. O_2.

1 lb. of carbon reacts with approx. 16 cub. ft. of oxygen (or 80 cub. ft. of air) to give 96 cub. ft. of gas containing 66.6 per cent. N_2, 33.3 per cent. CO. To which is added approximately 20 cub. ft. air to give a total of 106 cub. ft. of gas containing 20.5 per cent. CO, 7.6 per cent. CO_2, balance N_2, which has a CO/CO_2 ratio of 2.7 (see appendix). For every pound of carbon removed, therefrom, 106 cub. ft. of gas is produced.

Assuming there is a furnace filled with 2 tons castings averaging ¼ in. thick, then there is an area of something exceeding 1,800 sq. ft. The weight of carbon removed per hr. at various stages from curve (Fig. 6) would be:—

1st hour	...	...	43 lb. of carbon.
2nd hour	...	...	18 lb. of carbon.
5th hour	...	...	4.5 lb. of carbon
10th hour	...	...	1.8 lb. of carbon.
20th hour	...	...	1.3 lb. of carbon.

And the corresponding volume of gas produced would be:—

1st hour	...	...	4,560 cub. ft.
2nd hour	...	...	1,910 cub. ft.
5th hour	...	...	478 cub. ft.
10th hour	...	...	191 cub. ft.
20th hour	...	...	138 cub. ft.

As the cycle for this material is about 20 hrs. at temperature, it is evident that with a furnace holding 2 tons of these castings and the leakage rate of which is less than 138 cub. ft. per hr., it is possible to anneal without any external source of gas.

This example has been worked out for what is possibly one of the worst cases, namely a large surface area per unit of weight. With a charge of the same weight but of heavier section there will be less gas given off initially—in other words, a more gradual removal of carbon.

When the furnace is originally charged it will contain air, the volume of air in such a furnace being of the order of 100 cub. ft. As the furnace is charged at 600 deg. C., this represents approximately 31 cub. ft. at N.T.P. (neglecting any gas driven off by expansion on heating above 600 deg. C.). The volume of oxygen is 6.2 cub. ft., and its weight is 0.526 lbs. This corresponds with 1.91 lbs. of Fe_2O_4. This weight of oxide spread over 1,800 sq. ft. of charge represents a film 0.00004 in. thick, which is infinitesimal. In any case, it will be reduced as soon as CO is formed from the carbon content of the castings. It will be seen, therefore, that this constitutes a process[4] of annealing malleable iron castings in a controlled CO/CO_2 atmosphere without any gas other than that generated by the gas formed by the reaction C (in Fe) + $CO_2 \rightarrow$ (Fe) + 2CO, the carbon being provided from the castings.

If it is not possible or practicable to design a furnace which can be operated on the minimum gas generation, then a gas holder may be employed to store the surplus gas produced during the early stages which can be used as required during the later portion of the cycle. The total amount of gas produced from a 2-ton charge of ¼ in. thick castings is 13,000 cub. ft., or, over a period of 20 hrs., an average of 650 cub. ft. per hr. It is only necessary, therefore, by using gas storage in a gasholder, to build a furnace with a leakage factor of less than this volume. Another alternative is to run two or more furnaces in parallel off a recirculation gas circuit, and to stagger their operating cycles in such a way that when one furnace is producing its maximum volume of gas the other is producing at its minimum, and similarly with three furnaces.

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[4] C. Wells & R. F. Mehl, A. I.M.E., 140, 279 (1940).
[5] British Patent Application No. 19526/43.

(To be continued.)

"SIF-TIPS," Vol. 9, No. 52, the house organ of the Suffolk Iron Foundry (1920), Limited, Sifbronze Works, Stowmarket, contains a number of essentially practical articles dealing with various applications of welding.

GADGETS AND METHODS OF SUPPORTING CORES USEFUL TO THE JOBBING MOULDER*

By H. HOLDSWORTH

The Author does not claim to be the originator of these ideas, but he has seen and used them all at various times in his foundry career. Apart from their efficiency and ease of application is low cost of the parts which are, at least in overseas foundries, general foundry stock or can be made by the moulder in a few minutes.

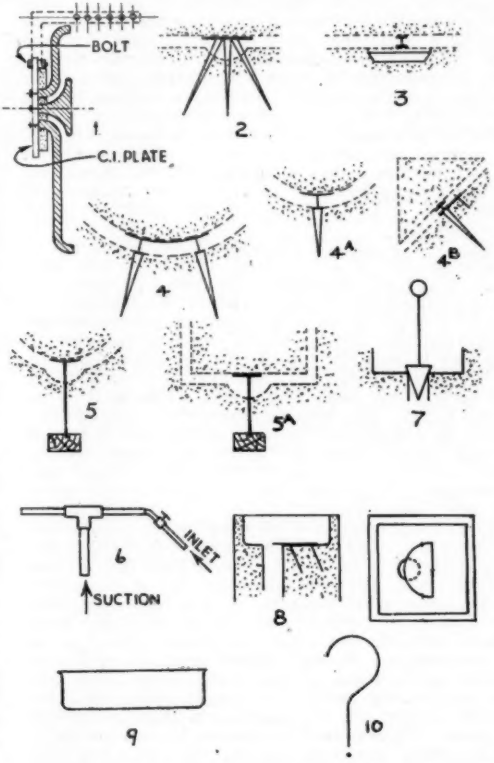
Fig. No. 1.—This method originated about 1921 when the firm received an order for sets of steam hammer castings. The sides and block were routine. It was when making the cylinder that some difficulty was experienced. The steam-chest plate had three prints on for the steam ports and exhaust port. The foundry made a suitable loam plate, and after it had been rammed up to steam chest, it was loamed up and bedded the plate into position. The staff rammed up the remainder; drew the body, then stripped off the loam plate, which was put to dry, the mould finished and put to dry. While this was being done, the men had to assemble the port cores on to the plate which had to be true to template; a drawing showing the correct metal thicknesses.

The mould was assembled, the bore core being placed in position. Now when the steam chest with holes provided in the plate was lifted, it was very lopsided, so the Author fixed a bar and had a man to balance it while it was being lowered into position—a matter of about 30 to 36 in. It will readily be imagined that the strain the three men had to use until it was in position was considerable, when there is only 1 in. metal, as the ports have to register against the bore core. When this was done, the elderly moulder in charge of the job said "I think I can cure that," and he went to the core bed and made two brackets which he bolted on to the plate. The holes cast along the top side permitted the finding of the correct balance. This system of lifting altered the method of making draw back plates, but that is another story.

Fig. No. 2 shows a method of giving a little extra support to a pipe nail. This happened when making some wheel guards. The job was made in the usual way and a pipe nail inserted to balance it; the wheel of the core pushed it down to the mould face. The Author was puzzling how to support it, as the metal was under ¼ in. thick, when the moulder said, "I'll show you how to fix that in a jiffy," and what he did was to put two 3-in. brads at a tangent with room for the pipe nail to go between and rest on the nails. The resistance is such that it has to be tapped to the metal thickness with a hammer.

Fig. No. 3 is not very original, but is a very useful, quick, and efficient method of putting a stud into a green sand mould. All it consists of is a cast-iron plate 3 in. by 3 in. by ⅛ in. bedded flush with the face of the mould, and the stud put central on it. It is not suitable for use on a machined face, as one is likely to get a hard spot at the joint, the plate having a chilling effect on the metal.

Fig. 4 is a method suitable for fairly heavy cores that can be used in either a green sand or dry sand mould. The method of fixing is simple and quick. First one makes what are called "cast-iron carrots"; the pattern used was the handle of the water brush pushed into the sand and filled with metal. A dozen



were made in a few minutes. The top face is ground flat; the position of the stud is decided upon and an impression is made with the round cuds of the stud. The carrots are then driven centrally in these marks until flush with the mould face, and the stud placed upon them. It can be used singly or on sloping faces. If on a sloping face, that is where the hole in the stud plate comes in, as one pushes a 1-in. joiner's nail through to hold it in position until the core is resting on it. If it is to be used on a dry sand mould, it is

* A Paper delivered to the South African branch of the Institute of British Foundrymen.

Gadgets and Methods of Supporting Cores

easier to place the carrots while the mould is still green. They can be easily located after the mould is dry, as the wet blacking and drying will cause them to rust slightly, thus showing their location.

Fig. 5 is an old method of giving support to a chaplet with a wooden block. Here again it can be used for pipe cores or block cores of considerable weight for jobs made in the floor. It is fixed by digging a hole where the chaplet has to be, large enough to allow the block of 3 by 3 by 3 to drop in to a depth of at least 4 in. below the mould face. Before it is dropped in, a sharpened spike is driven into the block for approximately ¼ in. for two reasons, first to ensure that the block will not split, and secondly for locating the chaplet. The block is then bedded down solid, then a spike of the same diameter as the stem of the chaplet is tapped into the block; the hole is rammed up, taking care to ram solid around the block; the mould face is finished off; the chaplet cut to the correct length, allowing for the thickness of metal plus ¼ in. to drive into the block to ensure that it is firm.

Fig. 6 is a gadget encountered since coming to South Africa. It is composed of ¼-in. T and three short pieces of ¼-in. piping. Its uses are many, for by a syphon action one can clean out the most delicate mould and get in the most awkward corners without doing the least damage, as the dirt is drawn out. It can also be used for blowing out a mould if desired. It is very useful for wet blacking and is very mobile for getting into awkward corners. This is done by using a 2-lb. jam tin and using the blacking very thinly, as it seems that the water is atomised off, leaving a thick coat of blacking. It has even been used for white-washing the foundry walls. The Author acknowledges with gratitude that the source of the syphon was Mr. Leon Cachet.

Figs. 7 *and* 8 deal with plugging runners as a means of preventing scum and dirt getting in with the metal. The ideal way is to keep the runner bush full, but the difficulty is in getting it full. The plug in the runner is one favoured for big jobs. This is made by casting the core on a mild-steel rod. In one shop they were always available in various sizes suitable for 1 in. to 3 in. downgate. Another method used for small jobs was to cut a piece of thin gauge tinned iron, and after making the runner-bush the moulder would lay the tin covering the downgate about three-quarters of its area. This was held in position by two moulders' brads. What happened was that the metal was held for one or two seconds to allow the bush to fill, when it collapsed, and the metal ran as desired, and the pourer—once he had the bush full—could keep it so.

Fig. 9 is a very simple method indicating when a box is not lifting or lowering level. Many will have seen the difficulty of lowering a box level, especially when it has a deep lift or cores bolted on it. What is done is to make a clear level spot in the centre of the box; then place on it a dish filled with water which all concerned can see, including the crane driver.

Fig. 10 is a notion which will not get the Author any medals from the moulder. The latter has, from force of habit, developed a technique of throwing an article on the floor when he has finished with it. Also, if he wants something he looks around on the floor and against the walls. The moral is that if ever the management wants to hide anything from a moulder, all it has to do is hang it up—he'll never find it.

In conclusion, the Author wishes to thank African Malleable Foundries, Limited, for their help in connection with this Paper and for the samples of the various articles shown.

DISCUSSION

MR. WATSON asked why the cylinder had been cast up on end.

MR. HOLDSWORTH replied that the pattern was so constructed that no other method would have been possible. The body of the whole job was made in one piece. The job was cast with an open head and fed from the top.

MR. WATSON said that at one time it was common practice to cast cylinders on end, the idea being to overcome the problem of dirt. Experience had shown, however, that for convenience it was better to cast a cylinder flat. By flattening it off 1½ in., dirt was eliminated. His firm had cast one 8-ton cylinder by this method, which he believed was still in action, and also many small ones.

MR. HOLDSWORTH said that the steam port core where it touched the body registered only in three spots, which allowed any dirt coming through to come up with the metal.

MR. WATSON said that in the first steam hammer his company used its own steel for the cylinder. One port core was 4 ft. long and the other 18 in. That job was cast on the side.

MR. TONGE congratulated Mr. Holdsworth on his Paper. He particularly appreciated its simplicity. The gadgets were so obvious that on that very account they were liable to be overlooked. Moulders were apt to forget them because they were so obvious, and he thought that the younger moulders would find them extremely interesting. He was surprised, however, that Mr. Holdsworth had never seen a gadget like Fig. 6 until he came to South Africa, as his device was used in the railway foundries of Yorkshire and Lancashire 40 years ago.

MR. WATSON asked which would be the better and safer method, a wooden block or a plate for the chaplet.

MR. HOLDSWORTH favoured the wooden block, which was an easier method. Moreover, if a plate was used the chaplet must be dead to size and the presence of any dirt would lead to difficulties. In the wooden block method this was taken care of by the wood.

MR. WATSON asked whether Mr. Holdsworth had ever had any difficulty with a plate, using a spike.

MR. HOLDSWORTH said that Mr. Watson had raised a point which was one of the aims of the Paper, by giving members alternative ideas.

The PRESIDENT said it was generally believed that chaplets fused in and actually became a part of the

casting. His opinion, however, was that it was very rare for a chaplet to be actually fused in.

MR. HOLDSWORTH was inclined to agree that a chaplet did not become part of the casting. If it did, there would be a possibility of damage resulting from the chaplet collapsing. At the same time, the chaplet had to be of such a shape that the metal would grip round it. He showed the meeting an overseas chaplet which had been nicked and tinned. As the metal got round it, the fusing action resulting from its affinity with the metal would give it a muff coating. A chaplet on a machined face could still be seen while it was being machined, and therefore could not have become part of the casting.

MR. WARD said that when a waster had been broken up and particular attention was paid to the chaplet, he had seldom seen a steel chaplet and never any cast-iron chaplet that had been fused in.

COL. GROSE asked whether Mr. Holdsworth agreed with the method of chiselling the end of a chaplet after cutting, and burring and riveting it over the lump formed in the casting.

Riveting Not Necessary

MR. HOLDSWORTH considered that it depended on the shop. He contended that if the moulder took into consideration the thickness of metal that he was dealing with and put in a sufficiently large button to ensure that the stud was tightly gripped, there would be no need for riveting. The end of the chaplet could even be cut off without any danger of a leak.

COL. GROSE said his experience was that the average fettler was inclined to cut the end off short.

MR. TONGE asked whether Mr. Holdsworth attached any importance to the coating of a chaplet in relation to its ability to fuse. In his opinion, coating was only a protection against rust during storage or transit. MR. HOLDSWORTH agreed and showed the meeting a pipe nail at least 15 years old, which showed no signs of rust.

MR. WATTS wondered whether it was due to the chilling effect that chaplets did not fuse; that is to say, whether there was insufficient metal round the chaplet to cause it to fuse properly with the surrounding metal.

The PRESIDENT believed that if too much support was expected from it, a perforated chaplet would collapse. It was often assumed that the chaplet was an integral part of the casting, but he maintained that rarely happened. If a chaplet became as hot as that it would collapse. Tin was generally regarded as the only efficient material for coating chaplets, zinc being unsuitable. The British Cast Iron Research Institute had issued a memorandum on chaplet coating, in which they suggested that the simplest method of testing the material for zinc was to drop it on a hot bush and see whether fumes were given off.

Replying to Col. Grose, MR. HOLDSWORTH said that with regard to the core iron, the method used for the cylinder mentioned in his Paper was to cast rods of the required length in a block, with provision for a staple and three vent holes, the three rods corresponding roughly and being cast straight up. The coremaker then used an open-topped box, bent his iron, and followed it round to his template. He always made a point of drying the cores on the coldest point of the stove; *i.e.*, on the floor. No trouble had been experienced.

Referring to the distortion of the core irons which his company had experienced, COL. GROSE said that this occurred when the irons were bent cold. Bending the irons had cured the trouble.

MR. WARD suggested that heating the irons reduced the stresses. Even the moderate heat of drying the cores might cause the core irons to straighten out.

COL. GROSE asked whether Mr. Holdsworth would prefer jagging or splaying for the 1½ in. arms of an 8-ft. sheave wheel. MR. HOLDSWORTH emphasised that he would prefer splaying.

COL. GROSE said that in all the wheels that had broken off, he had never seen the arm fused. He considered that chaplets very seldom fused.

MR. WARD suggested that when a chaplet showed up during machining, this might be due to the difference in the metal.

Danger of Rust

COL. GROSE asked whether the moisture condensing round a chaplet had any effect on the seal.

MR. HOLDSWORTH said this definitely pointed to the fact that the mould was not dry enough. Moisture percolated through and condensed on the cold stud. However, the moulder had to take a chance, hoping the hot metal was such that it would drive off the moisture. The only danger was rust.

Asked by the PRESIDENT whether a coating of oil would eliminate the danger of rust, MR. HOLDSWORTH considered that a film of oil might retard the action of the metal surrounding the stud. His company used to employ a mixture of red lead and paraffin, all the spokes put on sheave wheels being red lead painted. The rust should first be cleaned off to prevent further corrosion.

Asked about the runner plug which was No. 7 in his Paper, MR. HOLDSWORTH said that in plugging the runner bush a clearance of half an inch would have to be allowed when the shoulder was put on.

SPRING-SUPPORTED FORGE FURNACES

Accelerated war production, with resultant increase of shock vibration transmitted from hammers in a drop-forging plant, were causing the arches of adjacent furnaces to collapse after three months of operation. It was considered impractical at that time to use the positive vibration control method of mounting the hammers on isolating equipment. It was, therefore, decided to experiment with one furnace, mounting it in Korfund steel spring isolators, manufactured by the Korfund Company, Inc., Long Island City, N.Y. Since the furnaces are from 20 to 30 ft. long, 8 or 10 ft. wide, up to 10 ft. high and weigh loaded from 68 to 90 tons, heavy-duty isolators were needed. Satisfactory results achieved, says "The Iron Age," led the drop forging company to instal spring isolators under sixteen other furnaces.

A NEW TYPE OF HARDNESS TESTING MACHINE

W. & T. Avery, Limited, of Soho Foundry, Birmingham, 40, have designed a new Brinell hardness testing machine to meet the exacting demands of modern process control and scientific investigation. Tests requiring a high degree of precision can be carried out on the same standard machine, equally well with repetition tests for control purposes. It appears to be a great advance on the usual type of hardness testing machine. Consistent conditions can be maintained in any series of tests, as the machine, which is illustrated in Fig 1, is power operated, the load is applied at a controlled rate, and the rate of loading is adjustable.

A clear picture of the speed of load application is provided by a specially devised indicator, protected by a glass panel. Exceptional accommodation for sizeable specimens has been provided. The specimens are easily positioned, and the final adjustment is speedily performed. Ball-holders are quickly inserted and removed; they are retained in position by a snap action catch. The diameter of the impression is measured by means of a microscope, which is specially designed to read the diameters of impressions up to the 7-mm. limit for Brinell test.

General Description

The machine is of rigid cast-iron construction. All the working parts are encased, but easily accessible, and the machine has a clean, smooth, pleasing appearance. A single lever, mounted on knife-edges, applies the load. The lever carries a hanger for loose weights, which enable loads to be applied from 250 kgs. to 3,000 kgs. Elevation and lowering of the lever is operated hydraulically and is controlled by a small hand lever. The speed is set by a knob fixed adjacent to the indicator panel at the front of the machine. Excessive speed is prevented by the provision of a safety device in the hydraulic system. The range of speeds provide slow speed for special precision tests and relatively high speeds for repetition tests. Shock and impact loadings are avoided, as a feature in the machine is the slowing down of the speed of application of the load as it builds up. The indicator panel signals "set" position and speed of load application; moreover, it shows "no test" should the specimen be wrongly placed, or should there be any over-deflection or no specimen on the table. In none of these cases can damage to the machine result.

The specimen approach is open and free. A depth of 15 in. is provided and a distance of 7½ in. from the centre of the ball-holder to the machine column gives ample side space. The specimen, flat, round, or special shape, is placed on a hardened-steel platen or other fixture attached to a substantial elevating screw. The machine is placed at the "set" position by the hand-control lever. The handwheel elevates the platen to put the specimen in contact with the ball penetrator. Major adjustment is by means of this elevating screw handwheel, and final adjustment is made by a star handle on the ball-holder spindle.

For repetition tests, once the major adjustment is made, a fraction of a turn of the star wheel is all that is required to set the test for individual specimens. The electric motor and hydraulic pump are built into the machine. The motor casing is exposed for cooling. The push-button starter on the left of the machine and the control handle on the right, with speed control knob in front near the indicator panel,

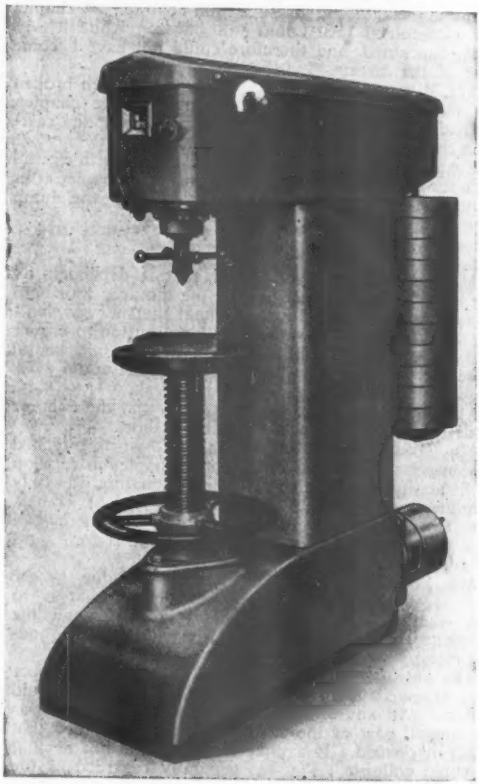


FIG. 1.—AVERY TYPE 64/1416 BRINELL TESTING MACHINE.

are all easily accessible to the operator sitting facing the indicator panel.

The elevating screw handwheel and the star handle adjusting the ball-holder are in front of the operator. This arrangement gives the operator a comfortable position for easy operation and safe control of the machine. The specimen, when under load, is at eye

(*Continued on page* 267.)

PRELIMINARY INVESTIGATION OF METAL POURING BY CINÉ RADIOGRAPHY

By S. L. FRY

Discussion on a Paper read at the annual meeting of the Institute of British Foundrymen. The Paper was printed in our issues of July 12 and 19.

MR. D. SHARPE (past-president), recalling that there had been much discussion during the last 10 or 12 years on the wetting of moulds when the metal was poured in, asked whether the apparatus dealt with in the Paper could be used to check up on the flow of the metal as it entered the mould. It would be very interesting if the apparatus could be so used to obtain definite information as to the manner in which the metal travelled along the face of the mould, whether the front was in the form of a wedge or a bubble. There had always been a lot of speculation on the matter, because it had been impossible to see the actual running of the metal.

MR. S. L. FRY replied that the first advantage of the method he had described was that it did show the flow of the metal; that was the simplest thing that one could find out by that technique. Generally speaking, the flow was not governed by the shape of the mould at all; it was governed entirely by the shape of the gate and the pressure and the direction of the runner. The metal merely filled up incidentally, finding its own shape. Numerous examples were already recorded where the jet forced its way through the accumulating metal in the mould and over the top, filling up the mould from the top face of the metal already in the mould.

The PRESIDENT (Mr. J. W. Gardom) asked whether the metal came in over the top with a convex or a concave front.

MR. FRY replied that the front was concave.

Use of Gamma Rays

MR. T. H. TURNER, M.Sc., congratulated the Author and Kent Alloys, Limited, on having given information such as one would expect to come from a research organisation, perhaps the National Physical Laboratory, the British Cast Iron Research Association or the British Non-Ferrous Metals Research Association. The company was certainly go-ahead, and he hoped it would derive great benefit from the work. No doubt, he continued, the use of gamma rays had been considered, and he asked why gamma rays had not been used. So far as thick sections of steel were concerned, the life of X-ray tubes was relatively so short that the maintenance of the X-ray plant became expensive. Therefore, one might just as well put one's capital into a radium salt and get one's money back later by the re-sale of the radium, for there was practically no capital loss. One should consider gamma rays as an alternative to X-rays for steel.

Commenting on the reference made to the flow of the metal in the mould, he said that he was more interested in the casting when it was made, and the tragedy of the use of X-rays or gamma rays was that, whereas they could detect blowholes, they did not show small cracks. Even some of the small blowholes were not detected. When a thick steel section was cut up, one could see cracks and blowholes sometimes even with the naked eye which the X-rays had not shown. The method described in the Paper was used for a novel purpose. It must be of much greater value that the founder investigate the casting process in the early stages, and be able to prevent the formation of blowholes and small cracks than that the user seeks them at a later stage.

MR. FRY, dealing with the question concerning the use of gamma rays, said that although he had had every encouragement from his company, he had had to use the apparatus employed on the routine examination of aircraft castings. That apparatus comprised a 200-kv. set and a 140-kv. set. At the moment the 140-kv. set was being used; so that it was not a question of kilovoltage, but rather of milli-ampères. He imagined that, when using gamma rays, there would not be nearly enough energy to make the screen fluoresce. The output was very low from radium, and he did not think it would be effective. One did not need short wavelengths; at this stage it was quantity not quality that was needed.

With regard to the point that X-rays could not pick up cracks or other fine defects, he said the radiologist would never claim to be able to detect cracks, but would probably claim everything else. The laboratory could pick up much by means of X-rays when using thin sections, because all the defects were added up into one plane, and very often there was difficulty in confirming the defects by metallographic means. However, very often the radiologist could pick up cracks.

MR. TURNER emphasised that he was thinking of thick steel, which was rather different from the light alloys.

MR. FRY said that he was interested only in aluminium castings, and he agreed that thick steel presented quite a different problem. But probably at a later date, with the higher-powered sets, sensitivity would increase.

MR. COX asked whether the Author had applied his technique to magnesium alloys, in which gas was not so bad as in aluminium, but where there were oxide inclusions and certain forms of micro porosity.

MR. FRY replied that he had not applied the technique to magnesium yet, but it was planned to do so. Some further progress would have to be made before micro defects inside the metal could be picked up; no doubt that would come, but it would be necessary to use more powerful equipment and much finer films. The limit of resolution was determined by the grain of the film and the grain of the fluorescent screen. If there were more power, so that those factors could be ignored, much more critical results could be obtained. The exposure could also be speeded up; at the moment it was about 1/60 sec., but with more output this could be shortened, and so the loss of definition, due to movement of the mould, could be reduced.

Metal Pouring by Ciné Radiography

No Fogging of the Film

MR. GLADWELL asked whether fogging of the film had been experienced.

MR. FRY said none had been experienced, although it was at first anticipated that lead glass would have to be used in front of the lens. All the lenses used on the camera were of heavy glass, and these were probably enough protection anyway. In practice, however, the problem did not arise, as the shutter opening moved over the film so rapidly that there was not enough time for the X-rays to fog the film. At the present time a thin sheet of lead glass in front of the lens was being used, but the sole function of this was to protect the lens from the action of the X-rays.

MR. F. H. SMITH (Association of Light Alloy Refiners) wrote: Mr. Fry in his verbal introduction mentioned that he experienced difficulty, in some of his later radiographs, in distinguishing between shrinkage porosity and that due to the liberation of dissolved gases. This difficulty may be partly overcome by ensuring in some of the experiments that the alloy used is, at the time of pouring, gas free. This may be easily determined by the vacuum solidification method described in the current Paper by Baker and Liddiard. This test is essential also if experiments investigating gas pick-up from mould surfaces are envisaged.

In his conclusions, the Author has suggested, as one of the future applications of his technique, "the high-speed examination of thin layers of metal with subsequent magnification." It would be of universal interest if the accepted principles of the nature of solidification of various alloys could be visually confirmed through the medium of ciné radiography. An alloy of, say, aluminium containing 10 per cent. copper, in which the primary dendrites would contrast sharply with the much higher density residual liquid, should prove ideal for the preliminary investigation of crystal growth, the movement of the alloy rich liquid, mass feeding and of inverse segregation. There are, however, unfortunately a number of factors which render such an investigation impracticable.

American practice in X-ray micrography (direct radiography), of which many interesting examples have been published, has been limited to the examination generally of slices up to 0.05 in. thick cut from castings, that is, a thickness of the order of the maximum grain size of the material. If greater thicknesses are examined the three dimensional crystal structure will become complicated, with crystals superimposed on others when reduced to the two dimensional screen or film. If, on the other hand, the examination, whilst freezing, of a very thin specimen is considered, it will be at once apparent that the conditions of solidification will be so abnormal as to render the result of little practical use. A mould capable of being temperature controlled might be constructed so that the rate of freezing could be sufficiently retarded, but even if this were practicable the manner of solidification must still be abnormal, and be governed by the very thin nature of the specimens. I would be very interested to hear the Author's views on this aspect.

Author's Reply

MR. S. L. FRY wrote: Dealing with the first point, I was not aware that shrinkage porosity was discussed at the meeting, and the only thing I think could have been confused with this was the question of difference between dissolved gas and trapped gas, which is a much more difficult problem.

In his experiments with regard to gas pick-up the intention is to watch the effect of any turbulence in the mould and not to try and decide afterwards where the gas came from. As far as I am aware, no method exists for determining the gas content of the metal before pouring, but only after solidification. The question of gas content, especially in DTD 304, has exercised resources of our laboratory to the full, but until it is possible to regulate the amount of gas present before pouring, this problem will still be unsolved.

In all of our experiments so far, certain defects have been encouraged to investigate the means of reducing the defect by variations in moulding technique, etc. In every case a comparison has been made; one good and one bad.

Before embarking on such critical examination necessary for the study of crystal growth, a number of refinements will have to be carried out on the X-ray and photographic side, and these will probably be more difficult to overcome than the purely practical problem of the rate of cooling, etc.

The use of a heated mould has been considered for some time, chiefly for the study of melting, chemical treatments, cooling conditions, etc., and no doubt by this means any rate of cooling desired could be aranged. Obviously compromises will have to be made in these special investigations between the practical and theoretical requirements, but it will be best to decide which when more knowledge is available.

CONFERENCE ON AUTOMATIC CONTROL

The Institution of Chemical Engineers, the Institute of Physics, and the Chemical Engineering Group of the Society of Chemical Industry announce that the one-day Joint Conference on "Instruments for the Automatic Controlling and Recording of Chemical and Other Processes," which was postponed in September last, will take place in the Royal Institution, London (by kind permission of the managers), on October 19 next. The purpose of the conference is to promote the interchange of knowledge and experience between those using automatic controllers and recorders in different fields and to encourage collaboration between physicists and chemical engineers. The conference will be open to all interested without charge.

FIVE-YEAR PLAN FOR THE STEEL INDUSTRY

Sir John Duncanson, who recently relinquished the post of Controller of Iron and Steel to become Commercial and Technical Director of the reconstituted British Iron and Steel Federation, stated last week-end that every part of the country will benefit from a big modernisation and reconstruction programme now under consideration. A considerable part of the plan has been approved and work on some of it has already commenced. The total cost will exceed £120,000,000 and the programme will be carried through as quickly as possible. Plans are being studied for the construction of new coke ovens to produce 2,500,000 tons of coke for the use of steelworks (£6,500,000), 19 new blast furnaces (£19,000,000), new melting shops (£20,000,000), replacement and reconstruction of rolling mills and a new continuous hot-strip mill in South Wales (£33,000,000), and ancillary processes (£16/19,000,000).

In addition, a further 10 blast furnaces are contemplated to replace existing furnaces as these go out. As there are at present 98 blast furnaces working in Great Britain, it will be seen that nearly one-third of these are to be rebuilt or replaced. Each of the new furnaces will be of the latest type. Apart from increased efficiency, the most important result of this will be that the capacity for total steel-ingot production in Great Britain will be increased by approximately 20 per cent.

Mechanisation of 28 Ironfoundries

With over-riding priority being given to building labour for house construction, progress on the modernisation plans will, of necessity, be slow at first. Work has already commenced on the rebuilding of four blast furnaces. The construction of new plant for the production of the latest type of hot-rolled sections for window casements for the housing programme has begun at Darlington, with new sectional mills for the rolling of light sections for the construction of buildings. Moreover, provision has been made for the complete mechanisation of 28 ironfoundries to meet the demand for baths, sinks, kitchen units and other household equipment has commenced. Although there are many hundreds of ironfoundries in the country, these 28 works, when completely mechanised, will be capable of producing more than 50 per cent. of the total output of iron castings.

Ninety per cent. of the new plant and equipment created during the war is of little or no post-war benefit, as this was undertaken to increase direct armament supply, such as steel casting facilities for bomb production, armour plate, tank track links, drop forging extensions and gun barrels, shell production and other specialised increases for a particular development of armament.

THE SHIPBUILDING EMPLOYERS' FEDERATION has returned to London offices at 1, Chester Street, Grosvenor Place, S.W.1.

FRENCH STEEL MISSION ENTERTAINED

The directors of the Metallurgical Equipment Export Company, Limited (MEECO), entertained the members of the French mission of steelmakers at luncheon at the Dorchester Hotel, London, W.1. Mr. Aron, Président de l'Office Professionnel de la Sidérurgie, was accompanied by Mr. Roux; Mr. Gautier and Mr. Cochenet, of the French Mission in London; Mr. Allard, Aciéries du Nord et de l'Est; Mr. de Beco, Fabrique de Fer du Maubeuge; Mr. Brun, Aciéries de la Marine et d'Homécourt; Mr. Crancie, Aciéries du Nord et de l'Est; Mr. Hué de la Colombe, Aciéries de Denain et d'Anzin; Mr. Marchall, Aciéries de Longwy; Mr. Martin, Office de la Sidérurgie in Paris; Mr. Minguet, Forges de Leval-Aulnoye; Mr. Montfort, Schneider et Cie; Mr. Piérard, de Wendel et Cie; and Mr. de Verchère, Etabs. Delattre et Frouard. Mr. Sieger, Mr. Ellis and Mr. Malborn, of the United Engineering & Foundry Company, of Pittsburgh, were also present.

The chairman, Mr. D. F. Campbell, in a short speech of welcome, explained that MEECO was an organisation of leading British makers of metallurgical plant who, under the guidance of Mr. F. G. Connor as managing director, were co-operating in the design and manufacture of complete metallurgical installations for export. He also expressed his pleasure at the presence of American friends, who were contributing their engineering skill to our efforts to reorganise the metallurgical industries of Europe.

A NEW TYPE OF HARDNESS TESTING MACHINE

(*Continued from page* 264.)

level; the machine can be mounted on a reasonably level bench or plinth; and no holding-down bolts are necessary.

Operation

The operator, who needs little skill, selects the ball-holder to be used and places the correct weights in position on the hanger; then, seated, presses the starter button, moves the control lever upwards, waits until the word "set" appears on the indicator panel, places the specimen in position on the platen, and elevates the platen by handwheel, making the final adjustment for contact between ball and specimen by the star wheel. The load is applied by moving the hand lever downwards. The rate of loading can be adjusted by means of the knob. The load is fully applied when the indicator shows no movement. Allowing the load to dwell for 15 secs., it is removed by the operator raising the hand-control lever and elevating the ball-holder to remove the specimen. The machine is now set for further tests.

The machine provides a quick, efficient and reliable means of making the Brinell hardness test. It is trouble-free, needs the minimum maintenance, and ordinary care and attention will keep it in constant operation.

IRON AND STEEL INSTITUTE

ANNUAL MEETING IN LONDON

The seventy-sixth annual meeting of the Iron and Steel Institute was held in London on July 11 and 12, Mr. Arthur Dorman (president) in the chair. The Institute of British Foundrymen were invited to take part.

The Bessemer gold medal was awarded to Mr. Harold Wright, chief metallurgist of Dorman, Long & Company, Limited, and the Williams Prizes for 1944 to Mr. G. D. Elliot, of the Appleby-Frodingham Steel Company, Limited, for Special Report No. 30, "Ironmaking at the Appleby-Frodingham Works of the United Steel Companies, Limited"; and to Mr. R. W. Evans, of Guest Keen Baldwins Iron & Steel Company, Limited, for his Paper on "The Heating of Open-hearth Furnaces with Mixed Coke Oven and Blast-furnace Gas."

The PRESIDENT intimated that at the meeting of the Council that morning they had nominated Dr. C. H. Desch, F.R.S., as president for next year. All members knew Dr. Desch, and the Council felt that the Institute would be fortunate to have him as president. The announcement was warmly received. The Council had also appointed Sir Peter Brown an honorary vice-president, in recognition of his long and distinguished service to the Institute. Prof. Thomas Turner had been elected an honorary member of the Institute. It was interesting to note that it was 60 years ago this year that Prof. Turner read his first Paper, on the effect of silicon on cast iron. It was printed in the "Journal of the Chemical Society" in 1885.

The SECRETARY (Mr. K. Headlam-Morley) said that, in accordance with Bye-law No. 10, the names of the following vice-presidents and members of Council were announced at the autumn meeting, 1944, as being due to retire by rotation at the present meeting. They were eligible for re-election:—*Vice-presidents*: Dr. C. H. Desch, F.R.S., Capt. H. Leighton-Davies, and Mr. J. S. Hollings, C.B.E.; *members of Council*: Mr. D. R. Lysaght, Mr. N. H. Rollason, Mr. E. J. Fox, Mr. J. Sinclair Kerr, and Mr. J. Mitchell. No other members having been nominated up to one month previous to the present annual meeting, they were now presented for re-election.

Annual Luncheon

Following the annual meeting, a luncheon was held at the Connaught Rooms, Kingsway, London, Mr. Arthur Dorman presiding. Some 400 members and guests were present.

MR. SPENCER SUMMERS (secretary, Department of Overseas Trade), proposing the toast of "The Iron and Steel Institute and Industries," said that during the past few years there had been produced a number of reports on the cotton trade, the coal trade, and other trades which had suggested, and quite rightly, the need for a substantial expenditure of capital. It was only to be expected that after six years of war, during which capital expenditure on modernisation and replacement was virtually impossible, great programmes of modernisation and expansion should be desired. But one result of those reports, and a result which he for one deplored, was the impression which they gave that we were lagging behind in the economic race, and that private enterprise had failed.

He hoped that that impression would not overlay the undoubted fact of the immense contribution which the steel industry had made, not only to the welfare of this country, but to the winning of the war in Europe. During that time the industry produced for war 72,000,000 tons of steel. In various other ways the industry had made a notable contribution. Tool steels used to need 18 per cent. of tungsten, which came from Burma. When those supplies were cut off, ways and means were found to replace them which provided the tool steel for the munitions industries of this country without which our programme could not have been carried out. During that time the industry had to use some strange raw materials.

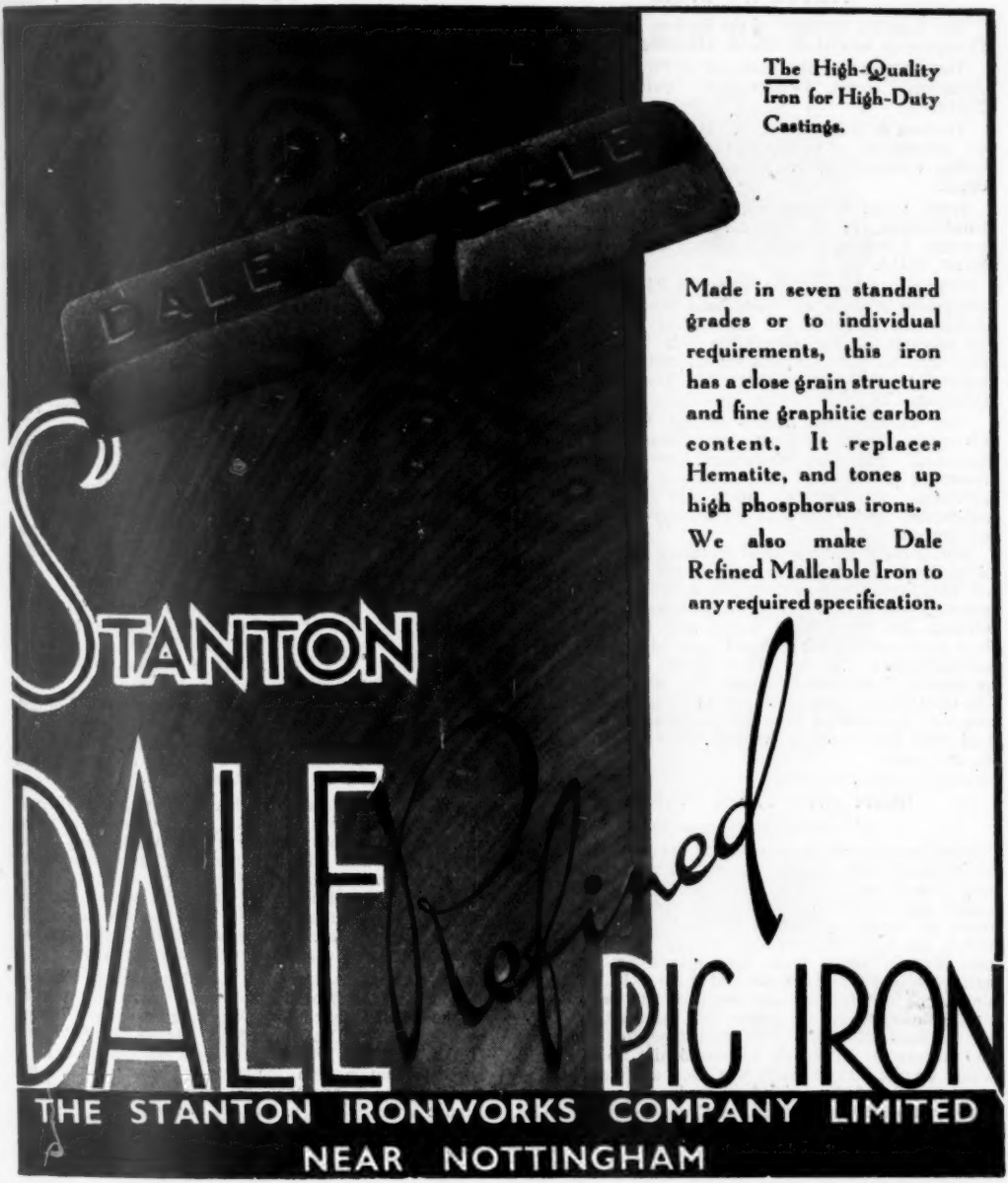
British Contribution to Science

Continuing, Mr. Summers recalled some of the directions in which Britain had made a notable contribution in the field of science, both for the winning of the war and for raising the standard of living in the days that lay ahead. For instance, the Mosquito carried the same bomb-load as the Flying Fortress, at 100 m.p.h. faster, and with a crew of two instead of a crew of 10. The Lancaster carried a greater bomb load than any other existing aircraft, and was the only one capable of carrying a 10-ton bomb. Those were British developments. Then with regard to engines. Where was there an engine comparable with the Rolls-Royce Merlin, the power of which had been doubled in five years? President Roosevelt, whose death all of us in this country deplored, paid a notable tribute to those who had made it possible for the British sparking plug for aircraft to be used in most American machines, as the result of the development of a special material, without which it would scarcely have been possible.

The electrical industry, said the speaker, had an equally fine record. The Battle of Britain might well have been lost if there had not been the warning which radiolocation enabled us to have, and no country could claim greater credit than Britain for the development of radiolocation. The use of that invention in aeroplanes was made possible only by the part which Imperial Chemical Industries played in the development of a certain insulating material. Many would remember in the early days of the war the announcements in the Press about the magnetic mine, and later how grave was the submarine menace, which might well have starved us out during the course of the war. It was British science and research and invention that produced the means to combat the magnetic mine and the submarine. The same story could be told of bomb sights and predictors and plastics.

In medicine, where publicity had already been rightly given to Penicillin and D.D.T., it was the same story. It had been possible to impregnate the shirts of the troops, particularly in the East, to guard them

(*Continued on page* 270, *col.* 1.)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NEWS IN BRIEF

THE LONDON ADDRESS of the Broken Hill Proprietary Company is now Ibex House, Minories, E.C.3.

THE ADDRESS of the Institute of Physics is now 19, Albemarle Street, London, W.1 (telephone, Regent 3541).

THOMAS & ISAAC BRADLEY, LIMITED, is being wound up voluntarily. Mr. G. T. Lunt, San Simeon, Newbridge Crescent, Wolverhampton, Staffs, is the liquidator.

JOHN LYNN & COMPANY, LIMITED, engineers and ironfounders, of Sunderland, have opened a new London office and branch agency at 49, Leadenhall Street, E.C.3.

THE FUNCTIONS of the Wrought Light Alloys Development Association have been taken over by the Aluminium Development Association, which includes all sections of the aluminium and aluminium-alloy industry. Communications should continue to be forwarded to Union Chambers, 63, Temple Row, Birmingham, 2.

THE TRINEC STEELWORKS of the Mining & Steel Company have resumed production in Czecho-Slovakia. The Brno armament works are gradually resuming production. It is believed that soon their precision instruments, automatic scales, slicing machines, typewriters and comptometers will appear on the market.

MR. JOHN BROWN, general secretary of the Iron and Steel Trades Confederation, giving the National Union of Blastfurnacemen and Kindred Trades his impressions on his tour of the iron and steel industries of Canada and the United States, said that the British iron and steel industry would have to meet increased competition in the world's markets from Canadian producers if the canal between the St. Lawrence and the Great Lakes was developed as a highway. Hitherto, one of the limiting factors operating in our favour had been the extensive haulage from Canadian mills to the coast.

IRON AND STEEL INSTITUTE

(*Continued from page* 268.)

against lice and the diseases which they carried. There were many more. Last, but by no means least, on that limited list, to which many more things could be added and would be added when security considerations no longer applied, there were the products in which the steel industry had played such a notable part, and in which many had played an individual part—Mulberry and Pluto and Fido. If he might single one out for especial mention, it was to the steel industry above all others that the credit was due for the production of the Bailey bridge, the tolerances and accuracies of which surpassed the normal, and which on the Italian front was used as frequently as one per mile of the ground covered.

The PRESIDENT responded, and also proposed "The Guests," the RT. HON. VISCOUNT GREENWOOD, P.C., responding to the toast.

PERSONAL

MR. F. C. CLAXTON has been appointed a director of the Wolverhampton Die Casting Company, Limited.

MR. D. B. HOSEASON has been appointed assistant managing director of the Brush Electrical Engineering Company, Limited.

MR. PERCIVAL BIANCHI has just returned from the United States as manager of the London office of the United States Steel Export Company.

MR. ROBERT WONFOR has been appointed managing director of Robert Boby, Limited, Bury St. Edmunds, in succession to the late Mr. H. Goodier.

MR. JAMES WHITE, D.Sc., Ph.D. (Glasgow), has been appointed lecturer in refractory materials in the Department of Metallurgy at Sheffield University.

MR. H. MOTZ has been appointed lecturer in engineering physics at Sheffield University. Mr. Motz is Dr. Ing. (Vienna), M.Sc. (Dublin), and M.A. (Oxford).

MR. BERNARD THOMAS, managing director of Midland Heat Treatments, Limited, Wolverhampton, has been appointed a director of Associated Edge Tool Industries, Limited.

MR. E. J. FOURACRE (sales manager) and MR. D. F. BROWN (assistant to the managing director) have been appointed to the board of directors of Westinghouse Brake & Signal Company, Limited.

PROF. ALEXANDER R. HORNE has received presentations on the occasion of his retirement from the Chair of Mechanical Engineering in the Heriot-Watt College, Edinburgh, which he has filled since 1929.

MR. W. V. HASLAM retired recently, due to ill-health, from the position of chief works engineer of the Bryan Donkin Company, Limited, Chesterfield, and has been the recipient of gifts from the staff and personnel of the maintenance department.

MR. J. H. ASTON, of Tube Investments, Limited, has resigned from the board of Stewarts and Lloyds, Limited. MR. P. G. CAREW, also of Tube Investments, Limited, has been appointed a director of Stewarts and Lloyds in place of Mr. Aston.

MR. T. P. NORRIS has been appointed adviser to Vickers-Armstrongs, Limited, on all matters concerning labour relations, welfare, apprentice training, medical services and kindred subjects. The company has long been vitally interested in such subjects, but is anxious to extend and co-ordinate the present arrangements. Mr. Norris has had wide experience in this sphere, having been concerned with similar matters in another large organisation for many years.

SIR LAWRENCE BRAGG, F.R.S., has been in Paris to lecture in French at the Sorbonne under the auspices of the British Council on "X-ray Analysis, Past, Present and Future," "The Strength of Metals," and "X-ray Optics." The visit was arranged in response to a request from French scientists. These lectures conclude a series arranged by the British Council in France since February, but the Council is assisting the British Institute in Paris over arrangements for future lecturers.

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Raw Material Markets

IRON AND STEEL

Production of pig-iron appears to be keeping pace with current requirements. There is no surplus available to augment stocks, which both at the blast furnaces and the foundries are of small proportions, but licences are sufficient for current needs, and it may be assumed that if, as is anticipated, more high-phosphorus iron is shortly needed for the light-castings trade, steps will be taken to increase production.

To maintain the sheet mills in full production, the supply of sheet bars has had to be substantially increased. This has only been accomplished by a contraction in the output of billets and some of the re-rollers are becoming urgent in their requests for increased tonnages. The position in regard to steel semis calls for careful supervision. Imports have come to a full stop, and it looks as though the resources of the steelmakers will be severely taxed to provide, unaided, the heavy tonnages of billets, blooms and sheet bars which will be needed to execute the re-rolling contracts already in hand. The activity of the sheet mills has been an outstanding feature for some time past, and new business is offered far in excess of the capacity of the mills. But there is now promise of considerable business in light sections, small bars, etc., for export and a number of orders are now being allocated.

Export orders and a better flow of specifications from the shipyards have led to a marked improvement in the position at the plate mills. Light and medium plates are now in strong request and delivery dates are extending. Trade in heavy joists and channels is dull, but the rail mills are working to capacity limits and the extent of visible requirements is such as to ensure the indefinite continuance of these conditions.

NON-FERROUS METALS

The American Copper Institute's figures for June show that output of crude copper was 72,169 short tons, compared with 74,469 tons in May, the corresponding totals for refined metal being 74,377 tons, against 85,319 tons. Deliveries to domestic users amounted to 94,031 tons, compared with 139,203 tons in May, while stocks of refined copper rose from 63,841 tons to 70,738 tons. There has been a pronounced decline in the American copper industry since March, when it reached its peak wartime effort. In that month domestic deliveries at 218,488 tons constituted an all-time record. The June figures, on the other hand, were the lowest for a long time past.

There is little indication that the authorities in the United Kingdom are going to make any early change in their present attitude over the release of statistics concerning non-ferrous metals, although the view is generally held that, the war with Germany being now over, the Control could make various details available to the trade. Even before the outbreak of war the statistical releases were not by any means satisfactory, and it is much to be hoped that the methods adopted for the compilation of figures by the Control during the war years will be continued and published in the future. Such a system would be of considerable assistance to the trade.

OBITUARY

MR. A. R. BELLAMY, a director of Ruston & Hornsby, Limited, and of Ruston-Bucyrus, Limited, has died at Grantham, aged 83.

MR. W. M. BROWN, formerly secretary and general manager of the Bede Metal & Chemical Company, Limited, Hebburn-on-Tyne, died recently. He was 86 years of age.

MR. T. B. BILTON, head and founder of T. B. Bilton & Sons, Limited, engineers and founders, of North Shields, died recently. He served his apprenticeship with the Wallsend Slipway & Engineering Company, and later began business on his own account.

MR. J. E. BETTS, who had completed almost 45 years' service with the British Thomson-Houston Company, Limited, died suddenly at his home in London on July 14. Mr. Betts held the position of supervisor of purchases for the B.T.-H. Company. Born in 1875 in Clifton, Bristol, he received his education at the Bristol Grammar School, and at the Merchant Venturers' Technical College, Bristol. In Bristol, too, he served an engineering apprenticeship with King, Mendham & Company, general electrical engineers. After holding engineering appointments in South Africa, Mr. Betts joined the outside construction staff of the B.T.-H. Company in 1900. In 1902 he was transferred to the construction staff at Rugby, and later was appointed manager of the factory production, stores, and order departments. In 1918 he was appointed supervisor of purchases for the B.T.-H. Company, and in 1931 became chairman of the group purchasing committee of Associated Electrical Industries, Limited. He held these appointments until his death.

PROF. PISEK, Dean of the Faculty of Metallurgy in the University of Brno, president of the Czechoslovak Foundrymen's Association, consultant to Kalcium A.S., the best-known Czech foundry equipment and supply concern, and a member of the London branch of the Institute of British Foundrymen, has emerged from existing "underground" for 3½ years with a price on his head, none the worse for his adventures.

DR. B. J. A. BARD has been appointed secretary of the F.B.I. Industrial Research Committee and head of the F.B.I. Research Secretariat. He began his professional life conducting fuel research, under the late Prof. W. A. Bone, F.R.S., at the Imperial College of Science and Technology. He then read for the Bar at Gray's Inn and practised at the Bar until the outbreak of war, after which he worked first with the Coal Commission and, later, on various industrial production and research problems at the Ministries of Supply and Aircraft Production.